

1. A positively charged glass rod touches the top of a neutral electroscope. The leaves on the rod separate. The rod is then removed from the electroscope.

(a) What observation would you make regarding the leaves of the electroscope now that the rod has been removed?

The leaves will repel each other.

(b) Briefly explain the reason for your observation.

The positively charged rod will strip away electrons from the electroscope. In the end, the rod will be less positively charged than in the beginning, and the electroscope will be short some electrons. Since the lack of electrons will be spread all over the electroscope (it is metal, and metal can conduct) the leaves will both be positively charged and will repel.

2. Object A has a charge of 3.6×10^{-12} C.

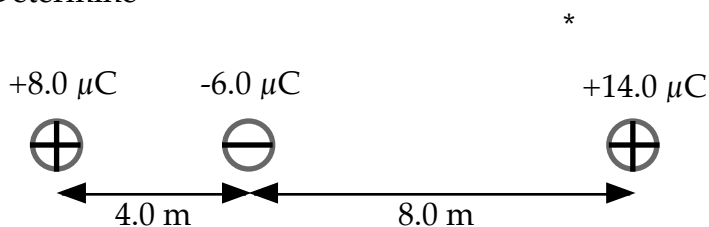
(a) What is the electric field strength 0.065 m away from object A?

$$E = kQ/r^2 \quad (9 \times 10^9)(3.6 \times 10^{-12})/(0.065)^2 \quad E = 7.7 \text{ N/C}$$

(b) A second object, Object B, has a charge of 8.4×10^{-11} C. Object B is placed 0.065 m from Object A. What force does Object B exert on Object A?

$$F = kQQ/r^2 \quad (9 \times 10^9)(3.6 \times 10^{-12})(8.4 \times 10^{-12})/(0.065)^2 \quad F = 6.4 \times 10^{-10} \text{ N}$$

3. Three charges are on a horizontal line with respect to each other. On the left is a $+8.0 \mu\text{C}$ charge, 4.0 m to the right is $-6.0 \mu\text{C}$ charge and 8.0 m further to the right is a $+14.0 \mu\text{C}$ charge. Determine



(a) the net force exerted by the other two charges on the $-6.0 \mu\text{C}$ charge and

$$F = kQQ/r^2 \quad (9 \times 10^9)(8 \times 10^{-6})(6 \times 10^{-6})/(4)^2 \quad F = 0.027 \text{ N to the Left}$$

$$F = kQQ/r^2 \quad (9 \times 10^9)(14 \times 10^{-6})(6 \times 10^{-6})/(8)^2 \quad F = 0.012 \text{ N to the Right}$$

$$0.027 - 0.012 = 0.015 \text{ N}$$

(b) the direction of the force on the $-6.0 \mu\text{C}$ charge. (RIGHT or LEFT will do.)

The force to the left is larger.. Overall force is to the left.

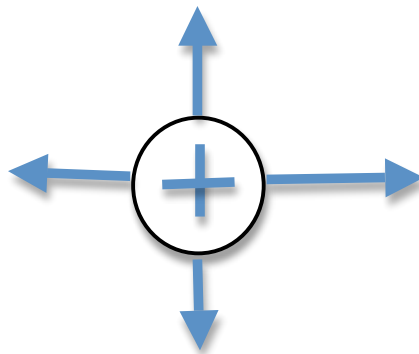
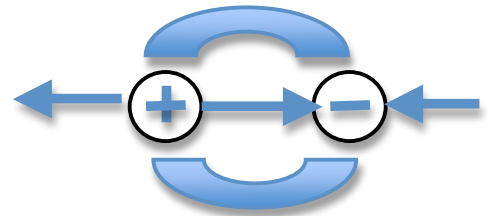
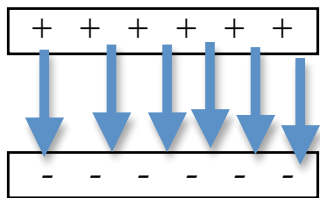
4. What does a battery supply that is necessary for electric current? Explain your answer briefly.

Energy. Without energy, the electrons would be unable to move. Essentially, the battery supplies the energy needed to give the charges kinetic energy. It really creates an electric field inside the circuit that makes the charges start to move "downhill" inside the field.

5. Is it possible to have an electric potential without an electric field? Explain your answer briefly.

No. Electric potential is similar to potential energy. Without a field to create the force, there is no energy. Think of gravity... if you raise a mass above the ground it has potential energy (mgh). But, if there is no gravity then raising a mass above the ground does not change its energy. It still won't fall!

6. Draw the electric field lines for the charged objects below.

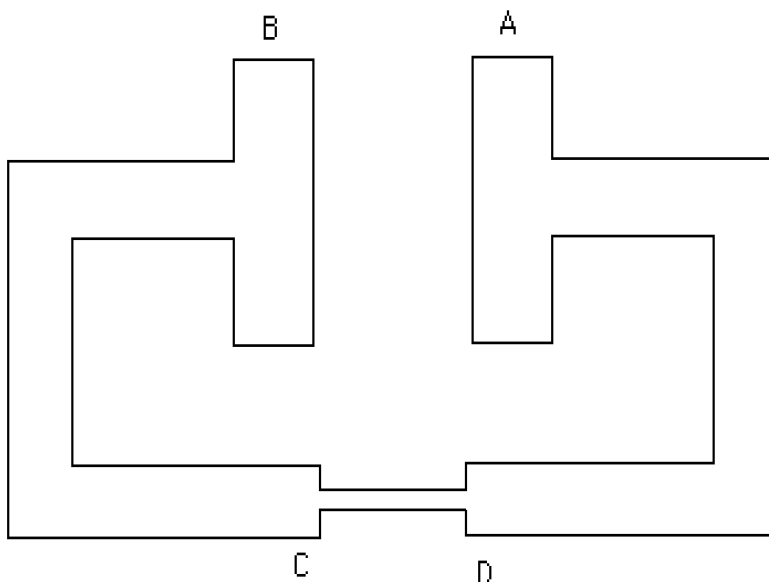


7. If a metal object is given a positive charge, does its mass increase, decrease, or stay the same? (even a very small change is a change)

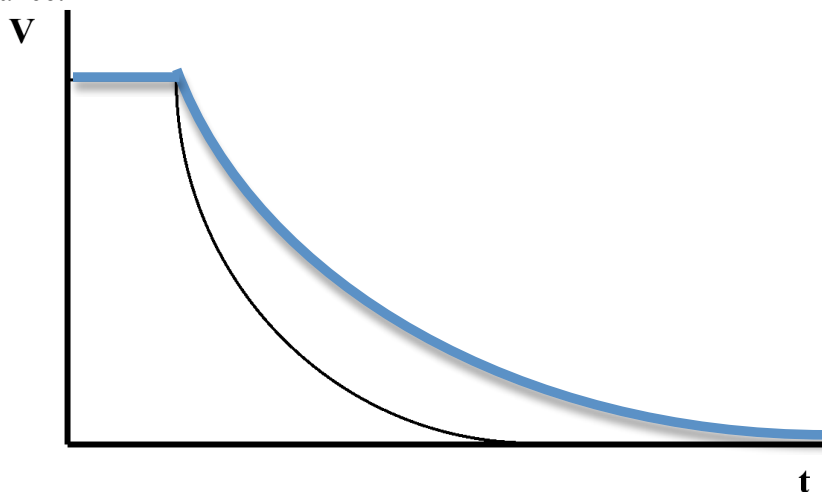
Decreases. Losing electrons positively charges metals. Loss of matter (electrons) means a loss of mass.

8. In the diagram at right, a capacitor is charged with a battery; the loose end at C is connected to one side of a bulb holder with a *long* bulb of **low** resistance. On the diagram below, sketch the distribution of charge, just after you connect the wire D to the bulb. Indicate the strength and direction of the electric field between A & B, B & C, C & D, D & A.

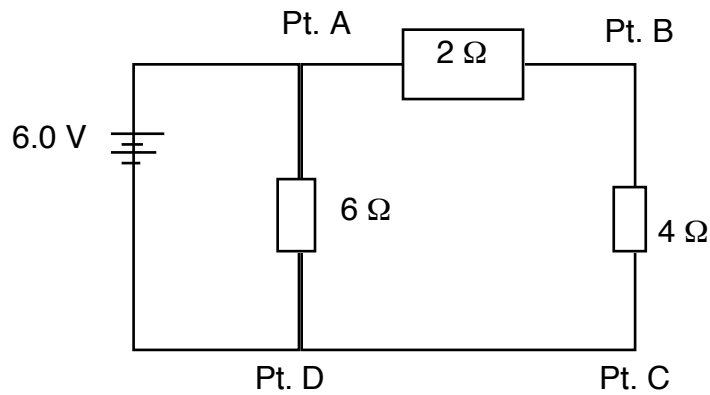
Strong field between A&B, Almost zero field between B&C and A&D, Strong field between C&D. Both strong fields point in the same direction, either left or right according to how you drew the charges.



The graph below shows how the potential changes when the loose end at D is connected to the other clip of the bulb holder. Sketch the graph of V vs t for the discharge of the capacitor through a *round* bulb with **higher** resistance.



9. Find the voltage and current at each of the labeled points.



Overall resistance = $1 / (1/6 + 1/6) = 3 \text{ ohms}$

Total current = $V/R = 6V/3 \text{ ohms} = 2A$

Point A = 2A, 6V (current has not been through anything yet.)

Point B = 1A, 4V (Current splits at point A, half goes down, half goes right. 2V are lost in the resistor $1A \times 2 \text{ ohms}$)

Point C = 1A, 0V (same current as point B, no voltage left... nothing to go through before returning to the battery)

Point D = 1A, 0V

10. A toaster heating a piece of bread, has a resistance of 145Ω when operating at a voltage of 120 V.

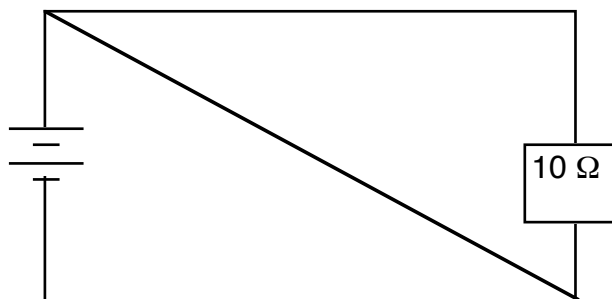
(a) How much power is being dissipated in the toaster as heat?

$$P = V^2/R = 120^2/145 = 99 \text{ W}$$

(b) How much work is being done by the toaster during the three minutes that it is heating the bread?

$$W = Pt = 99 \text{ W} \times 180 \text{ s} = 17,900 \text{ J}$$

11. In the circuit diagram below, why will the total resistance be 0 and not 10 ohms?



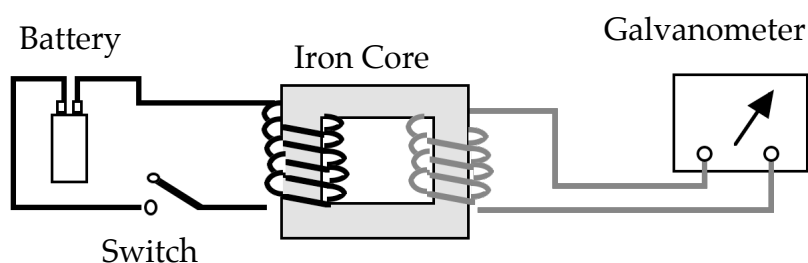
$$1/R_{\text{tot}} = 1/10 + 1/0$$

$R_{\text{tot}} = \text{zero... the middle wire is a short circuit.}$

12. An iron nail that does not display any magnetic properties is wrapped with a current carrying wire. When the nail's tip is brought near a compass, the compass needle deflects. Explain why this occurs.

A moving charge creates a magnetic field. Although all the charges in the nail are moving (electrons are always spinning around) their motion is random and cancels out. The motion of the charges in the current is not random, all the charges move in the same direction. Therefore the magnetic field is created.

13. By closing the switch in the left hand loop, a direct current is allowed to flow and the galvanometer needle flips to one side. After a short time, however, the needle on the galvanometer returns to the zero position even though the battery continues to provide a constant current. Explain why this happens.



Lenz's law says that a closed circuit will create a voltage (or a current) to oppose the change created in a circuit. When the switch is closed, a current suddenly begins to flow. This current causes a magnetic field in the iron core. The magnetic field in the core is new and needs to be opposed by the right hand side of the circuit. A current will be created through the galvanometer to oppose the B field. Once the current in the core is constant, there is no change to be opposed and the current in the galvanometer will drop to zero.

14. Use Lenz's law to explain why a magnet falls slowly through a copper tube, but falls much more quickly when dropped in a plastic tube.

Lenz's law says that a closed circuit will create a voltage (or a current) to oppose the change created in a circuit. The copper tube will allow a current to flow inside it to oppose the falling magnet (changing B field), but the plastic tube is NOT a conductor, so no current may flow. If no current flows to oppose the motion of the magnet, the magnet falls normally.

15. A wire is carrying a current of 15 A.

A. Determine the magnetic field strength 2.0 cm from the wire.

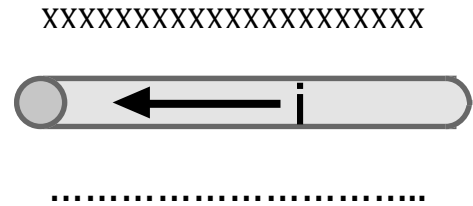
$$B = \mu I / 2\pi r = (4\pi \times 10^{-7})(15) / (2\pi)(0.02) = 1.5 \times 10^{-4} \text{ T}$$

B. At what distance from the wire would the magnetic field strength be $5.0 \times 10^{-6} \text{ T}$?

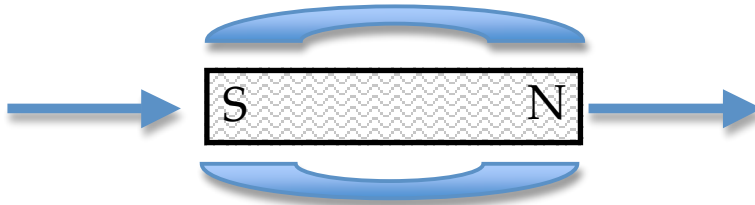
$$B = \mu I / 2\pi r \quad 5 \times 10^{-6} \text{ T} = (4\pi \times 10^{-7})(15) / (2\pi)(\text{Dist}) \quad \text{Dist} = 0.60 \text{ m}$$

16. For each of the following items draw in magnetic flux lines to show the general shape of the magnetic field.

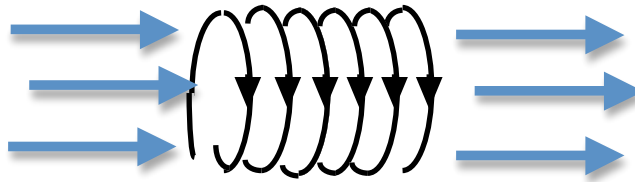
a. A wire carrying a current to the left.



b. A bar magnet



c. a solenoid with the current coming down in the front of the coil.



17. An electron passes through a magnetic field at right angles to the field at a velocity of 3.50×10^6 m/s. The strength of the magnetic field is 0.87 T.

(a) What is the magnitude of the force acting on the electron?

$$F = QVB = (1.6 \times 10^{-19})(3.5 \times 10^6)(0.87) = 4.9 \times 10^{-13} \text{ N}$$

(b) If the motion of the particle is at a 27.0° angle to the field find the force on the electron.

$$F = QVB \sin 21^\circ = (1.6 \times 10^{-19})(3.5 \times 10^6)(0.87)(0.36) = 2.2 \times 10^{-13} \text{ N}$$

18. A 300 turn rectangular loop of wire has an area of $5.0 \times 10^{-3} \text{ m}^2$. When a magnet is brought near the loop, the field inside increases from 0 T to 0.40 T in 0.55 s.

A. What is the magnitude of the Emf induced in the loop?

$$\text{Emf} = nBA/t = (300)(0.4-0.0)(0.005)/0.55 = 1.1 \text{ V}$$

B. If the loop has a resistance of 7.5Ω , determine the average induced current.

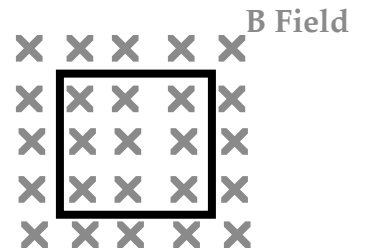
$$V = IR \quad 1.1 = (I)(7.5) \quad I = 0.15 \text{ A}$$

C. Using the diagram below state whether the current in the loop flows clockwise or counter clockwise in the loop.

Loop will want to get rid of new X's.
Current will flow counter clockwise to
produce dots that will cancel out X's.



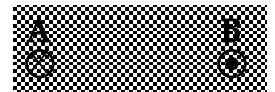
Loop at 0.0 s



Loop at 0.55 s.

19. The diagram at right shows two wires, A and B, which are oriented perpendicular to the plane of the paper. Note that the current is flowing in opposite directions.

- a. Sketch the direction of the magnetic field produced by wire B in the neighborhood of wire A.



B produces counter clockwise field, so its field is downward where it meets A

- b. Will the wires experience an attractive or repulsive force? Explain.

They will repel. Opposite currents repel. Use RH rule to prove that these two wires repel.

- c. What happens to the force on the A wire if

- i. the current in wire B is doubled?

The magnetic field will double so the force on A will double.

- ii. the distance between the wires is doubled?

If the distance doubles the force will be cut in half.

20. Which kind of mirror (concave or convex) can be used to start a fire with sunlight? Where should you place the material that you are hoping to burn? Explain your answers.

Use a concave mirror that brings light to a real focus. Put the object you want to burn at the focal point of the mirror. That is where all the light is concentrated.

21. A beam of light moving through air is incident at an angle of 37° onto a glass surface. If the angle of refraction is 22° find

A. The index of refraction for the glass

$$(1.00)(\sin 37^\circ) = n \sin 22^\circ \quad n = 1.22$$

B. The speed of light through the glass

$$n = c/v \quad 1.22 = 3 \times 10^8 / v \quad v = 2.5 \times 10^8 \text{ m/s}$$

C. The critical angle for the glass.

$$(1.2)(\sin ???) = (1.00)(\sin 90^\circ) \quad \text{Critical angle} = 56^\circ$$

22. A convex mirror is being used to monitor the aisles in a store. The mirror has a radius of curvature of 4.0 m.

A. What is the image distance if the customer is 18 m in front of the mirror?

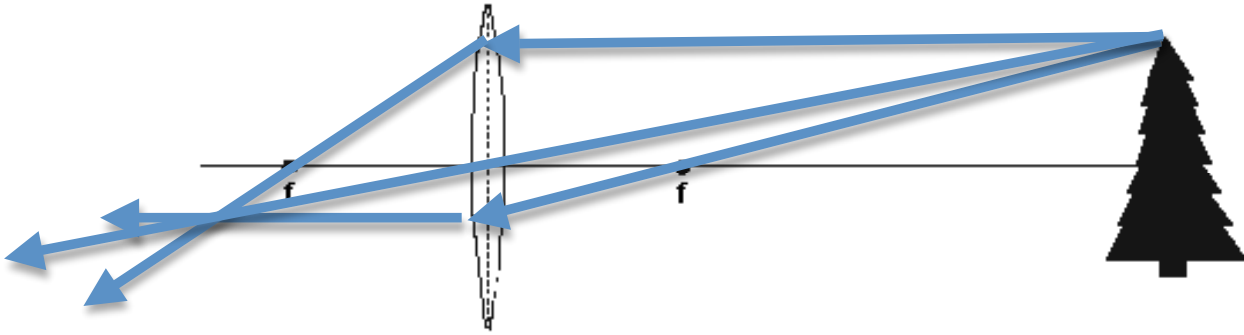
$$1/f = 1/d_o + 1/d_i \quad -1/4 = 1/18 + 1/d_i \quad d_i = -3.3 \text{ m}$$

B. If the customer is 1.4 m tall how tall is the image?

$$D_i/d_o = -h_i/h_o \quad 3.3/18 = h_i/1.4 \quad h_i = 0.26 \text{ m}$$

23. A bonsai tree 4.0 m from a lens ($f = 100$ cm) forms an image.

a. Sketch a ray diagram that shows the formation of the image.



b. How far from the lens is the image?

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \quad \frac{1}{1} = \frac{1}{4} + \frac{1}{d_i} \quad d_i = 1.33 \text{ m}$$

c. How tall is the image if the tree is 2.5 m high?

$$\frac{d_i}{d_o} = -\frac{h_i}{h_o} \quad -\frac{1.33}{4} = \frac{h_i}{2.5} \quad h_i = -0.26 \text{ m}$$